DESIGN NOISE STUDY REPORT
for the
I-85 Greensboro Bypass Section AB

NCDOT Project 8.U492301
TIP I-2402AB
FAP NHF-85-3(151)

Prepared for:

NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS

April 1998

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ATTENTION: Mr. Stephen E. Walker
Traffic Noise/Air Quality Section

RE: **DESIGN NOISE REPORT**
I-85 Greensboro Bypass, Design Section AB - Guilford County
From SR 1392 (Drummond Road) to East of SR 1007 (Randleman Road)
Project 8.U492301; FAP Project NHF-85-3(151); TIP I-2402AB.

Gentlemen:

The Design Noise Report for the I-85 Greensboro Bypass, Design Section AB is submitted to the Traffic Noise/Air Quality Section. The report contains minor revisions incorporated subsequent to FHWA review. The analysis was conducted in accordance with Title 23 CFR, Part 772, and NCDOT Noise Abatement Guidelines.

Should you have any questions regarding this report, please contact me at (717) 763-7211, extension 2428, or Daniel Farber at (717) 763-7211, extension 2613. We appreciate this opportunity to be of service to the North Carolina Department of Transportation on the Greensboro Bypass project and look forward to working with you on future projects.

Very truly yours,
Daniel W. Farber

for David R. Still, Manager
Transportation Noise/Air Quality Analysis

cc: Project I2402AB File

PROJECT LOCATION/DESCRIPTION

Design Section AB of the proposed I-85 Greensboro Bypass includes the construction of a freeway on new location from SR 1392 (Drummond Road) to east of SR 1007 (Randleman Road), a distance of approximately 3.3 km. Construction will be as a six-lane freeway for the entire length and will include a major interchange with existing US 220. Access will be fully controlled on the facility and the design speed is 110 km/h (70 m/h).

PROCEDURE

The highway traffic noise prediction requirements, noise analyses, noise abatement criteria, and requirements for informing local officials constitute the noise standards mandated by 23 CFR 772. All highway projects which are developed in conformance with this directive are deemed to be in conformance with the Federal Highway Administration (FHWA) noise standards.

The purpose of the FHWA procedures is to provide for noise studies and noise abatement measures to help protect the public health and welfare, to supply noise abatement criteria, and to establish requirements for information to be given to local officials for use in the planning and design of highways.

As part of this evaluation, existing noise levels were measured in the vicinity of the proposed project. Predictions were also made of the maximum design peak hour Leq traffic noise levels expected to occur at sensitive receptor locations in the vicinity of the project. The procedure used to predict future noise levels in this study was the FHWA Noise Barrier Cost Reduction Procedure, STAMINA 2.0 and OPTIMA (revised March 1983). The BCR (Barrier Cost Reduction) procedure is based upon FHWA Highway Traffic Noise Prediction Model (FHWA-RD-77-108).

CHARACTERISTICS OF NOISE

Sound is measured and described by units called decibels. Decibels are units which represent relative acoustic *energy* intensities. Because the range of energy found throughout the spectrum of normal hearing is so wide (whispers to jet engines) the scale used to define these levels must be able to represent huge variations in energy. To compensate for this wide range of numbers, a base 10 logarithmic scale is used to make the numbers more "normal".

Noise is an undesirable or unwanted sound as subjectively perceived by the individual. Noise is emitted from many sources including airplanes, factories, railroads, power generating plants, and highway vehicles. Acceptance of a certain noise level may vary among neighborhoods, individuals, and by the time of day. Sound can affect all human activities and is often considered in local and regional land use planning.

Traffic noise is the sound generated by automobiles and truck operations on streets and highways. The sound generated is composed of tire, engine, and exhaust noise. People respond differently to acoustic energy in varying frequency ranges. Frequencies are airborne vibrations described in cycles/second, cps, or Hertz, Hz. The faster the vibration, the higher the frequency. The normal range of healthy hearing is from 30 cps (very low) to 16,000 cps (very high). The human ear is most efficient in the mid and high range frequencies and has increasingly reduced efficiency below approximately 250 cycles.

Sounds heard in the environment usually consist of a range of frequencies, each at a different level. The method of correlating human response to equivalent sound pressure levels at different frequencies is called *weighting*. The weighting system used to correlate human hearing to frequency response is the *A-weighting* scale and the resultant sound pressure level is called the *A-weighted sound pressure level*, identifiable by the abbreviated descriptor dB(A). Traffic noise levels are presented in decibels, using the A-weighting scale.

Throughout this report, references will be made to dBA, which means an A-weighted decibel level. Several examples of noise pressure levels in dBA are listed in Table 1. Review of Table 1 indicates that most individuals in urbanized areas are exposed to fairly high noise levels from many sources as they go about their daily activities. The degree of disturbance or annoyance of unwanted sound depends essentially on three things:

1. The amount and nature of the intruding noise;

2. The relationship between the background noise and the intruding noise, and

3. The type of activity occurring when the intruding noise is heard.

In considering the first of these three factors, it is important to note that individuals have different hearing sensitivity to noise. Loud noises annoy some people more than others and some individuals may become angered if an unwanted noise persists. The time patterns of noise also enter into a person's judgement of whether or not a noise is objectionable. For example, noises occurring during sleeping hours are usually considered to be more objectionable than the same noises in the daytime.

With regard to the second factor, individuals tend to judge the annoyance of an unwanted sound in terms of its relationship to noise from other sources (background noise). The blowing of a car horn at night, when background noise levels are approximately 45 dBA, would generally be much more objectionable than the blowing of a car horn in the afternoon, when background noise levels might be 55 dBA.

The third factor is related to the disruption of an individual's activities due to noise. In a 60 dBA environment, normal conversation would be possible while sleep might be difficult. Work activities requiring high levels of concentration may be interrupted by loud noises while activities requiring manual effort may not be interrupted to the same degree.

Over a period of time, individuals tend to accept the noises which intrude into their daily lives, particularly if the noises occur at predicted intervals and are expected. Attempts have been made to regulate many of these types of noises including airplane noises, factory noise, railroad noise, and highway traffic noise. In relation to highway traffic noise, methods of analysis and control have developed rapidly over the past few years.

NOISE ABATEMENT CRITERIA

To determine if highway noise levels are compatible with various land uses, the FHWA has developed noise abatement criteria and procedures to be used in the planning and design of highways. These abatement criteria and procedures are in accordance with Title 23 Code of Federal Regulations (CFR), Part 772, U.S. Department of Transportation, FHWA, *Procedures for Abatement of Highway Traffic Noise and Construction Noise.* A summary of the FHWA Noise Abatement Criteria (NAC) for various land uses is presented in Table 2. Substantial increase, as defined by the NCDOT Noise Abatement Guidelines, is presented in Table 3. Sound pressure levels in this report are referred to as Leq(h). The hourly Leq, or equivalent sound level, is the level of constant sound which in an hour would contain the same acoustic energy as the time-varying sound. In other words, the fluctuating sound levels of traffic noise are represented in terms of a steady-state noise level of the same energy content. Also, one factor for considering traffic noise mitigation is when future noise levels either approach or exceed the criteria levels for each activity category. Title 23 CFR, Section 772.11(a) states, *In determining and abating traffic noise impacts, primary consideration is to be given to exterior areas. Abatement will usually be necessary only where frequent human use occurs and a lowered noise level would be of benefit.* For this project, all the identified receptors were residential, church, or commercial land use.

AMBIENT NOISE LEVELS

Ambient noise is that which results from natural and mechanical sources and human activity, and that which is considered to be usually present in a particular area. Ambient noise measurements were taken to quantify the existing acoustic environment and to provide a base for assessing the impact of future traffic generated noise levels from the proposed freeway on the receptors in the vicinity of the project. Field measurements were taken using a Bruel and Kjaer 2230 Precision Integrating Sound-Level Meter. The microphone was located at strategic points, 15 m from the near lane of travel and at an elevation approximately 1.5 m above the existing ground. A total of eight noise measurement sites were identified in the Greensboro Bypass Design Section AB project area. The ambient measurement sites and measured noise levels are presented in Figure 2 and Table 4, respectively.

The existing roadway and traffic conditions were used with the most current traffic noise prediction model in order to predict existing noise levels for comparison with measured noise levels. Comparisons were conducted at measurement sites 1, 3 and 6. The remaining five sites were not calibrated for one of two reasons. Either the roadways carried insufficient traffic, or were not clearly visible from the measurement site which prevented accurate traffic counts. The predicted existing noise levels ranged from 0.7 to 4.3 dBA higher than the measured noise levels at the three calibrated sites. Differences in dBA levels can often be attributed to "bunching" of vehicles, low traffic volumes, and actual vehicle speeds versus the computer's "evenly-spaced" vehicles and single vehicular speed.

The noise level of 51 dBA measured on Fisher Hill Drive (Measurement Site 8) was established as the ambient background noise level for the project area. At this background location, noise levels were comprised of birds singing, occasional hammering and dogs barking in the distance. There were no vehicle passbys during the measurement period.

PROCEDURE FOR PREDICTING FUTURE NOISE LEVELS

The prediction of highway traffic noise is a complicated procedure. Generally, traffic is composed of a large number of variables which describe different vehicles driving at different speeds through a continually changing highway configuration and surrounding terrain. To assess the problem, certain assumptions and simplifications must be made.

The procedure used to predict future noise levels in this study was the Noise Barrier Cost Reduction Procedure, STAMINA 2.0 and OPTIMA (revised March 1983). The BCR (Barrier Cost Reduction) procedure is based upon the FHWA Highway Traffic Noise Prediction Model (FHWA-RD-77-108). The BCR traffic noise prediction model uses the number and type of vehicles on the planned roadway, their speeds, the physical characteristics of the road (horizontal and vertical alignment, grades, cut or fill sections, etc.), receptor location and height, and, if applicable, barrier type, barrier ground elevation, and barrier top elevation.

Please note that only preliminary alignment was available for use in this noise analysis. The proposed roadways and intersections were assumed to be flat and at-grade. Therefore, the analysis represents the "worst-case " topographical conditions. Noise predictions made in this report were based on traffic conditions projected for the year 2015. Design hour volumes and truck percentages were derived from estimated 2015 ADT's and vehicle composition data provided by NCDOT's Traffic Forecast Unit. Design hour volumes were lower than level of service C volumes on all of the roadways studied within the project area. The speed of 105 km/h (65 m/h) was used for all freeway predictions.

The computerized model was used to determine the number of land uses (by type) which would be impacted during the peak hour in the design year 2015. The basic approach was to select receptor locations at 7.5, 15, 30, 60, 120, 240, and 480 m from the center of the near traffic lane (adaptable to both sides of the roadway). The result of this procedure was a grid of receptor points along the project alignment. Using this grid, noise levels were predicted for each sensitive receptor identified along the project. Receptors predicted to approach or exceed the FHWA NAC or to experience an NCDOT substantial increase in noise levels were then analyzed in detail.

TRAFFIC NOISE IMPACT AND NOISE CONTOURS

Traffic noise impacts occur when the predicted traffic noise levels either: [a] approach or exceed the FHWA noise abatement criteria (with "approach" meaning within 1 dBA of the Table 2 value), or [b] substantially exceed the existing noise levels. The NCDOT definition of substantial increase is indicated in Table 3. Consideration for noise abatement measures must be given to receptors which fall into either category.

In accordance with NCDOT Traffic Noise Abatement Policy, the federal/state governments are no longer responsible for providing noise abatement measures for new development for which building permits are issued within the noise impact area of a proposed highway after the Date of Public Knowledge. The Date of Public Knowledge of the location of a proposed highway project will be the approval date of CEs, FONSIs, RODs, or the Design Public Hearing, whichever comes later. For development occurring after this public knowledge date, local governing bodies are responsible to insure that noise compatible designs are utilized along the proposed facility.

Detailed traffic noise exposures for noise sensitive receptors located within the project area are listed in Table 5. Noise modeling along Section AB of the bypass was divided into two segments, one to the east and one to the west of US 220, based on differences in traffic volumes. Noise modeling was also conducted at representative receptors located along US 220 to the north and south of the proposed bypass alignment. No major construction or horizontal alignment shifts are proposed for US 220 in these areas. Predicted increases in noise levels are a result of growth in future traffic volumes.

The maximum number of receptors in each activity category that are predicted to become impacted by future traffic noise is shown in Table 6. These are noted in terms of those receptors expected to experience traffic noise impacts by approaching or exceeding the FHWA NAC or by a substantial increase in exterior noise levels. Under Title 20 CFR Part 772, there are 19 Category 'B' receptors along the bypass and 67 Category 'B' receptors along US 220 that are expected to experience traffic noise impacts in the project area. One Activity Category 'C' receptor, located along the bypass, is predicted to be impacted.. The maximum extent of the 72 and 67 dBA noise level contours are 67.0 and 110.5 m, respectively, from the center of the nearest travel lane. This information should assist local authorities in exercising land use control over the remaining undeveloped lands adjacent to the roadway within local jurisdiction. For example, with the proper information on noise, the local authorities can prevent further development of incompatible activities and land uses with the predicted noise levels of an adjacent highway.

Table 7 indicates the anticipated increase in exterior traffic noise levels for the identified receptors in each roadway section. When real-life noises are heard, it is possible barely to detect noise level changes of 2-3 dBA. A 5 dBA change is more readily noticeable. A 10 dBA change is judged by most people as a doubling or a halving of the loudness of the sound. Predicted noise level increases for this project are generally under 10 dBA, however predictions indicate that approximately 8 receptors would experience a substantial increase in noise levels (≥ 10 dBA) by the design year of 2015 as a result of the construction of the Greensboro Bypass Section AB.

TRAFFIC NOISE ABATEMENT MEASURES

If traffic noise impacts are predicted, examination and evaluation of alternative noise abatement measures for reducing or eliminating the noise impacts must be considered. Consideration for noise abatement measures must be given to all impacted receptors. There are 86 Activity Category 'B' receptors and 1 Activity Category 'C' receptor impacted due to highway traffic noise in the project area.

Highway Alignment Selection

Alignment selection involves the horizontal or vertical orientation of the proposed improvements in such a way as to minimize impacts and costs. The selection of alternative alignments for noise abatement purposes must consider the balance between noise impacts and other engineering and environmental parameters. For noise abatement, horizontal alignment selection is primarily a matter of citing the roadway at a sufficient distance from noise sensitive areas. The proposed construction of Design Section AB of the Greensboro Bypass has been evaluated to provide a balance among travel needs, safety of the motoring public, and other engineering and environmental parameters.

Traffic System Management Measures

The mission of the I-85 Greensboro Bypass transportation corridor is regionally significant in the efficient movement of people and goods. Traffic system management measures which limit vehicle type (e.g., heavy trucks), speed, volume, and time of operations, may be effective noise abatement measures. For this project, however, traffic management measures are not considered appropriate for noise abatement due to their adverse effect on the capacity and level-of-service of the widened freeway.

Past project experience has shown that a reduction in the speed limit of 10 mph would result in a noise level reduction of approximately 1 to 2 dBA. Because most people cannot detect a noise reduction of up to 3 dBA and because reducing the speed limit would reduce roadway capacity, it is not considered a viable noise abatement measure. This and other traffic system management measures, including the prohibition of truck operations, are not considered to be consistent with the project's objective of providing a high-speed, limited-access facility. These relationships among the change in sound pressure level, acoustic energy, and loudness are depicted in Table 8.

Noise Barriers

Noise barriers reduce noise levels by blocking the sound path between a roadway and noise sensitive areas. This measure is most often used on high-speed, limited-access facilities where noise levels are high and there is adequate space for continuous barriers. The range of feasible barrier attenuation (insertion loss or sound reduction) is presented in Table 9. Noise barriers may be constructed from a variety of materials, either individually or combined, including concrete, wood, metal, earth and vegetation.

For a noise barrier to provide sufficient noise reduction it must be high enough and long enough to shield the receptor from significant sections of the highway. Access openings in the barrier created by driveways or intersections severely reduce the noise reduction provided by the barrier. It then becomes economically unreasonable to construct a barrier for a small noise reduction. For example, an observer (receptor) located 15 m from the barrier would normally require a barrier 120 m long. An access opening of 12 m (10 percent of the area) would limit its noise reduction to approximately 4 dBA (*Fundamentals and Abatement of Highway Traffic Noise*, Report No. FHWA-HHI-HEV-73-7976-1, USDOT, chapter 5, section 3.2, page 5-27). Hence, these factors would not allow noise walls to be acceptable abatement measures along the right-of-way that is not controlled. Additionally, pedestrian and motorist safety at noise barrier access openings (driveways, crossing streets, etc.) is of primary concern due to the restricted sight distance from the observer to oncoming traffic.

In order for a noise barrier to be considered feasible, it must meet, among other factors, the following conditions:

1. Provide a minimum insertion loss of 6 dBA, preferably 8 dBA or more (for receptors directly adjacent to the project);
2. Result in an acoustic environment where no other noise sources are present; and
3. Be feasible to construct given the topography of the location.

A primary consideration of the reasonableness of noise barrier installation is that it costs no more than $25,000 per receptor benefitting (those impacted or non-impacted receptors receiving 4 dBA or more reduction).

Due to traffic noise impacts predicted to occur by the design year 2015, a noise barrier evaluation was conducted for this project. The evaluation consisted of a qualitative analysis conducted at the locations listed below. Consideration was given to the FHWA NAC activity category at each receptor, source-receptor relationships, impacted site densities, and the ability to have continuous barriers.

<u>Qualitative Analysis</u>:

- <u>Receptors 9 through 15 & 19:</u> Eight residences located along SR 1124 (Roberts Court) and SR 1392 (Drummond Road) in the southwest quadrant of the Greensboro Bypass/US 220 Interchange. Four of these receptors would be impacted as a direct result of traffic on the proposed bypass. Three receptors would be impacted because of increased traffic on local roads, and one would be impacted by the combined total of traffic noise from all roadways. A barrier system in this location would not be cost effective because only the four receptors impacted totally by the bypass would benefit. The barrier would be ineffective in mitigating future noise levels for the receptors impacted either partially or totally by traffic on local roads.

- Receptor 26: Isolated commercial receptor along SR 1392 (Drummond Road) in the northwest quadrant of the Greensboro Bypass/US 220 Interchange. Mitigation would not be reasonable because of the cost of abatement versus the benefits provided.

- Receptor 38: Isolated residence south of the proposed alignment along SR 1115 (Rehobeth Church Road). Mitigation would be unreasonable due to the cost of abatement versus the benefits provided.

- Receptor 43: Isolated residence south of the proposed alignment along SR 1104 (Old Randleman Road). Mitigation would be unreasonable due to the cost of abatement versus the benefits provided.

- Receptors 48 through 52: Five residences located south of the proposed alignment along SR 1107 (Randleman Road). Mitigation along the bypass would not be feasible for these receptors because impacts would be as a result of traffic noise from SR 1107 (Randleman Road).

- Receptors 64 through 66 & 70: Four isolated residences north of the proposed alignment along SR 1107 (Randleman Road). Construction of a barrier to abate noise levels would not be reasonable because of the cost of abatement versus the benefits provided. In addition, several residences would be impacted by noise from traffic on local roads making a barrier along the bypass ineffective at these locations.

- Receptors 1, 4, 7 & 8 (Along US 220): Representing approximately 66 residential dwellings and a school, these receptors would be impacted because of an increase in future traffic volumes on US 220. Since no major improvements or horizontal alignment shifts are proposed for US 220, the impacts would be due entirely to future traffic volumes. According to NCDOT noise policy, mitigation for receptors along existing US 220 is considered unreasonable because noise levels would increase by 3 dBA or less over existing levels.

CONSTRUCTION NOISE

The major construction elements of this project are expected to be pile driving, earth removal, hauling, grading, and paving. General construction noise impacts, such as temporary speech interference for those individuals living or working near the project, can be expected. Construction noise impacts may be particularly noticeable during paving operations, earth moving, and grading operations. Overall, construction noise impacts are expected to be minimal, since the construction noise is relatively short in duration and is generally restricted to daytime hours. Furthermore, the transmission loss characteristics of building shells are considered sufficient to moderate the interior effects of intrusive construction noise.

SUMMARY

Noise impacts are an unavoidable consequence of roadway projects. A total of 19 residences (FHWA NAC "B") and 1 commercial establishment (FHWA NAC "C") are predicted to experience impact by highway traffic noise with the construction of the Greensboro Bypass Design Section AB. It was determined that noise barriers are not considered reasonable and are not recommended for these impacted receptors for one or both of the following reasons:

- Most residences are isolated or located in small communities. Costs would not be justified because the number of residences benefiting would be minimal.
- Traffic noise from Y-line roadways would be the dominant noise source at several impacted receptors. Mitigation of the proposed bypass would be ineffective in these areas.

In addition to the receptors impacted directly by the construction of the Greensboro Bypass Design Section AB, approximately 66 residences and 1 school athletic field would be impacted because of an increase in future traffic volumes on US 220. Since no major improvements or horizontal alignment shifts are proposed for US 220, the impacts would be due entirely to future traffic volumes. Mitigation for receptors along US 220 is considered unreasonable because noise levels would increase by 3 dBA or less over existing levels.

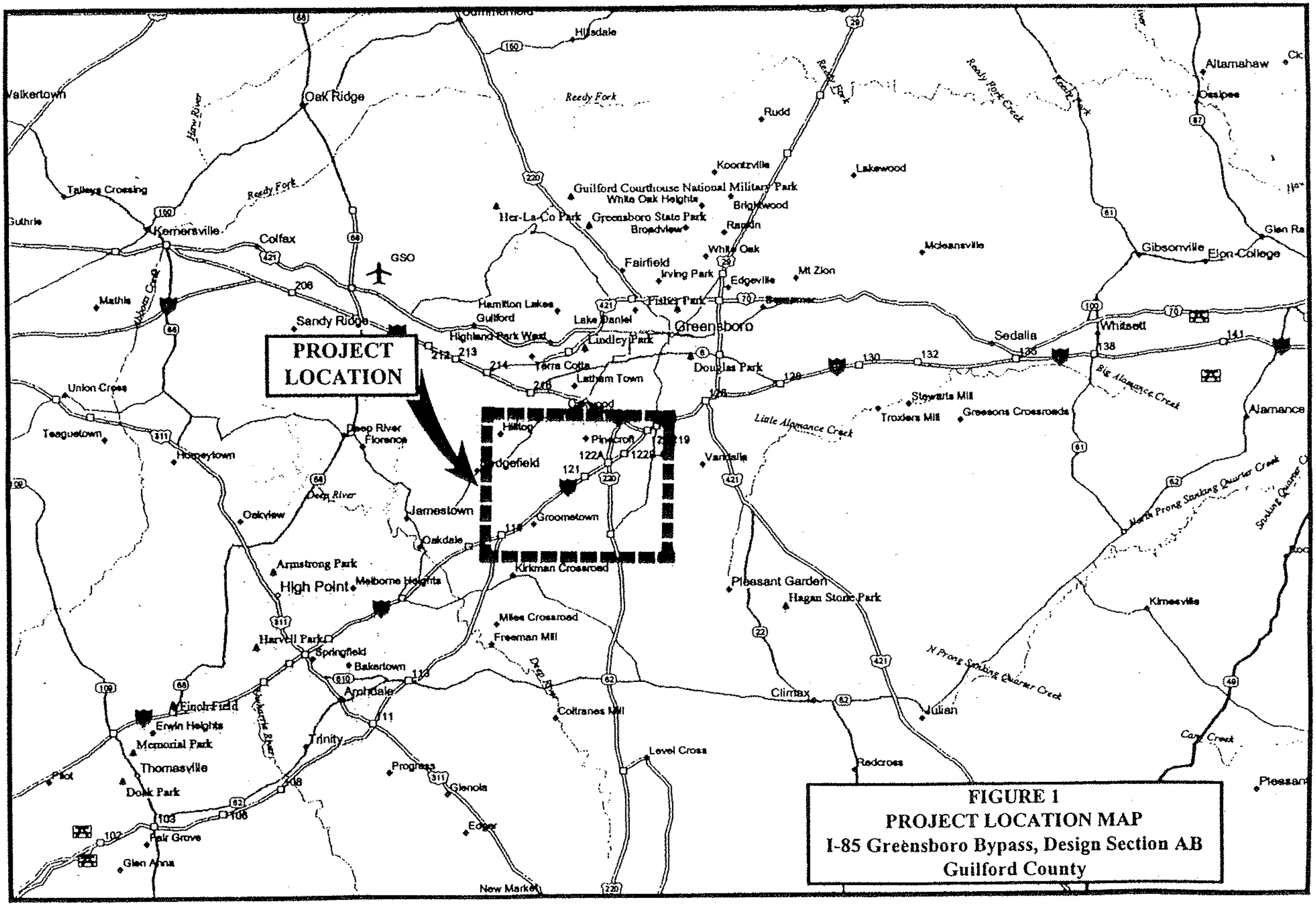

FIGURE 1
PROJECT LOCATION MAP
I-85 Greensboro Bypass, Design Section AB
Guilford County

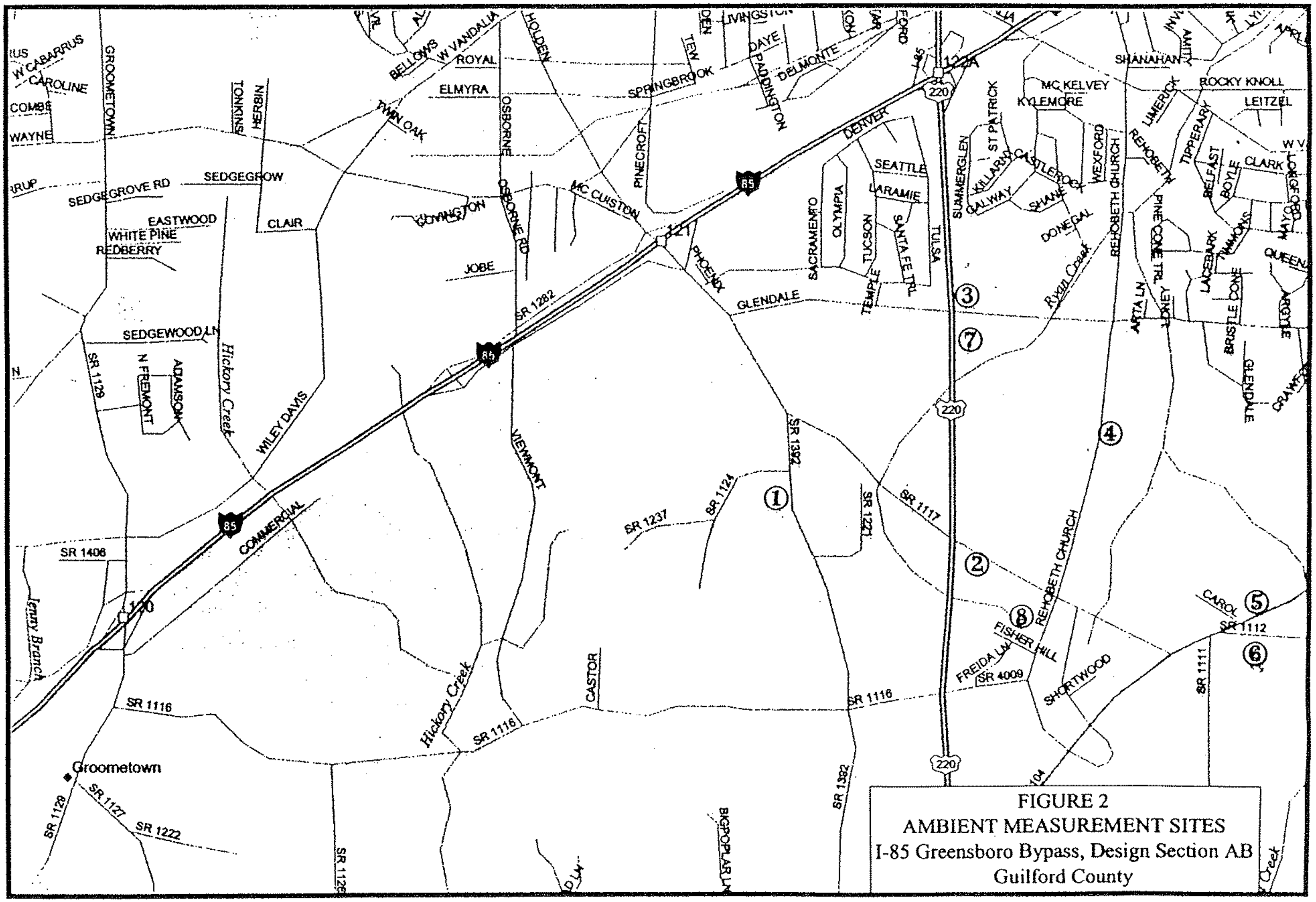

FIGURE 2
AMBIENT MEASUREMENT SITES
I-85 Greensboro Bypass, Design Section AB
Guilford County

Table 1
Hearing: Sound Bombarding Us Daily

OVERALL EFFECT	DBA	DESCRIPTION
PAIN	140	Shotgun blast, Jet 30 m away at takeoff Motor test chamber
THRESHOLD OF PAIN	130	Firecrackers
	120	Severe thunder, Pneumatic jackhammer Hockey crowd
UNCOMFORTABLY LOUD	110	Amplified rock music Textile loom
LOUD	100	Subway train, Elevated train, Farm tractor Power lawn mower, Newspaper press
	90	Heavy city traffic, Noisy factory Diesel truck 65 kph @ 15 m
	80	Crowded restaurant, garbage disposal Average factory, vacuum cleaner
MODERATELY LOUD	70	Passenger car 80 kph @ 15 m
	60	Quiet typewriter Singing birds, window air conditioner Quiet automobile
QUIET	50	Normal conversation, Average office Household refrigerator
VERY QUIET	40	Quiet office
	30	Average home Dripping faucet
AVG. PERSON'S THRESHOLD OF HEARING	20	Whisper @ 1.5 m Light rainfall, rustle of leaves
JUST AUDIBLE	10	Whisper
THRESHOLD OF ACUTE HEARING	0	

Table 2
Federal Highway Administration
Noise Abatement Criteria
Hourly A-Weighted Sound Level - Decibels (dBA)

Activity Category	$L_{eq}(h)$	Description of Activity Category
A	57 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need, and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries and hospitals.
C	72 (Exterior)	Developed lands, properties or, activities not included in Categories A or B above.
D	--	Undeveloped lands.
E	52 (Interior)	Residences, motels, hotels, public, meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

Source: *Procedures for Abatement of Highway Traffic Noise And Construction Noise*, 23 Code of Federal Regulations (CFR) Part 772; December 1991

Table 3
Definition of Substantial Increase
Hourly A-Weighted Sound Level - decibel (dBA)

Existing Noise Level in Leq(h)	Increase In dBA From Existing Noise Levels To Future Noise Levels_
≤ 50	≥ 15
> 50	≥ 10

Source: North Carolina Department of Transportation Noise Abatement Guidelines.

Table 4
Summary of Existing Ambient Noise Level Measurements

Sect.	Location	Description	Date	Time[1]	Monitored Existing Noise Level dBA, Leq(h)
1	4400 Drummond Road	field across from residential area	1/21/97	3:02 pm	63
2	4112 Holden Road	front yard of residence	1/21/97	3:41 pm	61
3	US 220	grassy cut section	1/21/97	4:49 pm	74
4	Living Way Christian Fellowship Church, Rehobeth Church Road	grassy area in front of church	1/21/97	4:21 pm	57
5	Sumner Baptist Church Old Randleman Road	paved parking lot adjacent to church	1/21/97	8:15 am	60
6	3400 Randleman Road	field next to Kallamdale Road	1/21/97	7:27 am	67
7	Nugget Ridge Apartments	grassy area adjacent to US 220 right-of-way	1/23/97	8:49 am	65
8	Fisher Hill Drive at Frieda Lane	grassy area next to pond	1/23/97	9:19 am	51

1. Time indicates start of measurement period. Measurements were 30 min. in duration at all locations.

Table 5
Greensboro Bypass
Design Section AB
Predicted Traffic Noise Levels Leq(h), dBA

A. GREENSBORO BYPASS, WEST OF US 220 INTERCHANGE													
Receptor Information		Nearest Existing Roadway	Dist. (m)(1)	Ambient Noise Level(2)	Nearest Proposed Roadway	Dist. (m)(3)	Predicted Noise Levels			Impacts(4) Land Use Category			IOE
ID#	Land Use Category						L	Y	Total	B	C	E	
1	Residence B	Drummond Road	582	51	Greensboro Bypass, West of US 220	372	53	<40	53				2
2	Residence B	Drummond Road	530	51		366	53	<40	53				2
3	Residence B	Drummond Road	469	51		326	54	<40	54				3
4	Residence B	Drummond Road	415	51		329	54	<40	54				3
5	Residence B	Drummond Road	427	51		265	56	<40	56				5
6	Residence B	Drummond Road	366	51		274	56	<40	56				5
7	Residence B	Drummond Road	280	51		329	54	<40	54				3
8	Residence B	Drummond Road	293	51		274	56	<40	56				5
9	Residence B	Drummond Road	256	51		152	63	<40	63				12
10	Residence B	Drummond Road	225	51		134	65	<40	65				14
11	Residence B	Drummond Road	24	61		88	69	64	70	*			9
12	Residence B	Drummond Road	37	57		134	65	60	66	*			9
13	Residence B	Drummond Road	18	62		180	61	65	66	*			4
14	Residence B	Drummond Road	61	53		165	62	56	63				10
15	Residence B	Drummond Road	12	64		201	60	67	68	*			4
16	Residence B	Drummond Road	27	60		250	57	63	64				4
17	Residence B	Drummond Road	21	61		256	57	64	65				4
18	Residence B	Drummond Road	46	56		346	54	59	60				4
19	Residence B	Drummond Road	15	63		328	54	66	66	*			3
20	Residence B	Drummond Road	18	62		376	53	65	65				3
21	Residence B	Drummond Road	125	51		291	56	54	58				7
22	Residence B	Drummond Road	140	51		218	59	54	60				9
23	Residence B	Holden Road	73	51		315	55	51	56				5
24	Residence B	Holden Road	31	57		254	57	59	61				4

Note
1. Distance to centerline of near lane of existing roadway.
2. Shaded areas indicated receptors where ambient noise levels were adjusted up to 51 dBA, the existing ambient background noise level.
3. Distance to centerline of near lane of proposed roadway.
4. * indicates traffic noise impact (per 23 CFR Part 772).

Table 5
Greensboro Bypass
Design Section AB
Predicted Traffic Noise Levels Leq(h), dBA

A. GREENSBORO BYPASS, WEST OF US 220 INTERCHANGE														
Receptor Information			Nearest Existing Roadway	Dist. (m)(1)	Ambient Noise Level(2)	Nearest Proposed Roadway	Dist. (m)(3)	Predicted Noise Levels			Impacts(4) Land Use Category			
ID#	Land Use Category							L	Y	Total	B	C	E	IOE
25	Residence	B	Holden Road	73	51	Greensboro Bypass, West of US 220	242	57	51	58				7
26	Business	C	Holden Road	36	56		132	65	59	66				10
27	Residence	B	Holden Road	15	61		136	64	50	64				3
28	Residence	B	Holden Road	21	59		126	65	45	65				6

Notes
1. Distance to centerline of near lane of existing roadway.
2. Shaded areas indicated receptors where ambient noise levels were adjusted up to 51 dBA, the existing ambient background noise level.
3. Distance to centerline of near lane of proposed roadway.
4. * indicates traffic noise impact (per 23 CFR Part 772).

Table 5
Greensboro Bypass
Design Section AB
Predicted Traffic Noise Levels Leq(h), dBA

B. GREENSBORO BYPASS, EAST OF US 220 INTERCHANGE														
Receptor Information			Nearest Existing Roadway	Dist. (m)(1)	Ambient Noise Level(2)	Nearest Proposed Roadway	Dist. (m)(3)	Predicted Noise Levels			Impacts(4) Land Use Category			IOE
ID#	Land Use Category							L	Y	Total	B	C	E	
29	Residence	B	Holden Road	55	52	Greensboro Bypass, East of US 220	297	56	48	57				5
30	Residence	B	Holden Road	24	59		303	55	46	56				(3)
31	Residence	B	Holden Road	24	59		334	54	45	55				(4)
32	Residence	B	Holden Road	24	59		346	54	45	55				(4)
33	Residence	B	Holden Road	24	59		358	54	44	54				(5)
34	Residence	B	Holden Road	24	59		376	53	43	53				(6)
35	Residence	B	Holden Road	24	59		394	53	<40	53				(6)
36	Church (5)	E	Holden Road	27	34		303	30	<40	30				(4)
37	Residence	B	Holden Road	9	63		334	54	<40	54				(9)
38	Residence	B	Holden Road	213	51		163	62	<40	62				11
39	Church (5)	E	Holden Road	37	30		340	29	<40	29				(1)
40	Residence	B	Old Randleman Road	207	51		224	58	<40	58				7
41	Residence	B	Old Randleman Road	122	51		267	57	46	57				6
42	Residence	B	Old Randleman Road	47	52		285	56	55	59				7
43	Residence	B	Old Randleman Road	18	59		132	65	62	67	*			8
44	Residence	B	Old Randleman Road	15	60		297	56	63	64				4
45	Residence	B	Old Randleman Road	15	60		309	55	63	64				4
46	Residence	B	Old Randleman Road	15	60		328	55	63	64				4
47	Residence	B	Old Randleman Road	15	60		346	54	63	64				4
48	Residence	B	Randleman Road	31	62		163	62	65	67	*			5
49	Residence	B	Randleman Road	24	64		242	58	67	68	*			4
50	Residence	B	Randleman Road	15	67		285	56	70	70	*			3
51	Residence	B	Randleman Road	27	63		218	59	66	67	*			4
52	Residence	B	Randleman Road	24	64		291	52	67	67	*			3

Notes
1. Distance to centerline of near lane of existing roadway.
2. Shaded areas indicate receptors where ambient noise levels were adjusted up to 51 dBA, the existing ambient background noise level.
3. Distance to centerline of near lane of proposed roadway.
4. * indicates traffic noise impact (per 23 CFR Part 772).
5. Noise levels represent interior levels (FHWA Category E) and include a 25 dBA insertion loss for masonry construction.

Table 5
Greensboro Bypass
Design Section AB
Predicted Traffic Noise Levels Leq(h), dBA

B. GREENSBORO BYPASS, EAST OF US 220 INTERCHANGE														
Receptor Information			Nearest Existing Roadway	Dist. (m)(1)	Ambient Noise Level(2)	Nearest Proposed Roadway	Dist. (m)(3)	Predicted Noise Levels			Impacts(4) Land Use Category			IOE
ID#	Land Use Category							L	Y	Total	B	C	E	
53	Residence	B	US 220	232	51	Greensboro Bypass, East of US 220	419	52	50	54				3
54	Residence	B	US 220	280	51		410	52	48	53				2
55	Residence	B	US 220	329	51		431	52	46	53				2
56	Residence	B	US 220	402	51		425	52	44	53				2
57	Residence	B	US 220	479	51		434	52	42	52				1
58	Residence	B	US 220	488	51		443	52	<40	52				1
59	Residence	B	US 220	576	51		443	52	<40	52				1
60	Residence	B	Rehobeth Church Road	37	51		196	60	<40	60				9
61	Church (5)	E	Rehobeth Church Road	33	31		215	39	<40	39				8
62	Residence	B	Rehobeth Church Road	24	51		264	57	<40	57				6
63	Residence	B	Rehobeth Church Road	37	51		315	55	<40	55				4
64	Residence	B	Randleman Road	73	55		56	74	58	74	*			19
65	Residence	B	Randleman Road	31	62		212	59	65	66	*			4
66	Residence	B	Randleman Road	91	52		181	61	55	62				10
67	Residence	B	Randleman Road	146	51		193	60	50	60				9
68	Residence	B	Randleman Road	213	51		205	60	45	60				9
69	Residence	B	Randleman Road	396	51		230	58	<40	58				7
70	Residence	B	Randleman Road	366	51		148	64	<40	64				13

Notes
1. Distance to centerline of near lane of existing roadway.
2. Shaded areas indicate receptors where ambient noise levels were adjusted up to 51 dBA, the existing ambient background noise level.
3. Distance to centerline of near lane of proposed roadway.
4. * indicates traffic noise impact (per 23 CFR Part 772).
5. Noise levels represent interior levels (FHWA Category E) and include a <u>20 dBA</u> insertion loss for <u>frame</u> construction.

Table 5
Greensboro Bypass
Design Section AB
Predicted Traffic Noise Levels Leq(h), dBA

C. US ROUTE 220, NORTH AND SOUTH OF GREENSBORO BYPASS														
Receptor Information			Nearest Existing Roadway	Dist. (m)(1)	Ambient Noise Level(2)	Nearest Proposed Roadway	Dist. (m)(3)	Predicted Noise Levels			Impacts(4) Land Use Category			IOE
ID#	Land Use Category(5)							L	Y	Total	B	C	E	
1	Residence (29)	B	US 220, North of Bypass	45	67	US 220	45	NA	69	69	*			2
2	Residence (24)	B	US 220, North of Bypass	98	60	North of Bypass	98	NA	62	62				2
3	Residence (30)	B	US 220, North of Bypass	128	57		128	NA	59	59				2
4	Residence (13)	B	US 220, North of Bypass	49	66		49	NA	68	68	*			2
5	Residence (12)	B	US 220, North of Bypass	104	59		104	NA	62	62				3
6	Residence (12)	B	US 220, North of Bypass	166	54		166	NA	56	56				2
7	Residence (24)	B	US 220, North of Bypass	61	64		61	NA	67	67	*			3
8	School(2)(6)	E	US 220, North of Bypass	58	40		58	NA	42	42				2
9	School Athletic Field	B	US 220, North of Bypass	31	70		31	NA	72	72	*			2
10	Residence (1)	B	US 220, South of Bypass	213	51	US 220	213	NA	53	53				2
11	Church(1)(7)	E	US 220, South of Bypass	46	47	South of Bypass	46	NA	49	49				2
12	Residence (3)	B	US 220, South of Bypass	183	52		183	NA	55	55				3

Notes
1. Distance to centerline of near lane of existing roadway.
2. Shaded areas indicate receptors where ambient noise levels were adjusted up to 51 dBA, the existing ambient background noise level.
3. Distance to centerline of near lane of proposed roadway.
4. * indicates traffic noise impact (per 23 CFR Part 772).
5. The number of receptors.represented by each modeled location are indicated in parenthesis.
6. Noise levels represent interior levels (FHWA Category E) and include a <u>25 dBA</u> insertion loss for <u>masonry</u> construction.
7. Noise levels represent interior levels (FHWA Category E) and include a <u>20 dBA</u> insertion loss for <u>frame</u> construction.

Table 6
FHWA Noise Abatement Criteria Summary

Description	Maximum Predicted Leq Noise Levels [1]			Contour Distance (maximum)[2]		Approximate Number of Receptors Impacted According To Title 23 CFR Part 772				
	15m	30m	60m	72 dBA	67 dBA	A	B	C	D	E
Greensboro Bypass, west of US 220 Interchange	82.5	78.4	72.9	65.7	108.3	0	8	1	0	0
Greensboro Bypass, east of US 220 Interchange	82.7	78.6	73.1	67.0	110.5	0	11	0	0	0
Totals: Bypass Section AB						0	19	1	0	0
US 220, north of Greensboro Bypass	76.4	72.2	66.8	30.8	58.3	0	67	0	0	0
US 220, south of Greensboro Bypass	76.6	72.5	67.0	31.9	60.0	0	0	0	0	0
Totals: US 220						0	67[3]	0	0	0

Notes:

1. 15m, 30m, and 60m distances are measured from center of nearest travel lane.
2. 72 dBA and 67 dBA contour distances are measured from center of nearest travel lane.
3. Impacts along US 220 are a result of predicted increases in traffic. No major construction or horizontal alignment shifts are proposed for US 220.

Table 7
Traffic Noise Level Increase Summary

Section	Exterior Increase In Noise Level At Sensitive Receptors							Substantial Noise Level Increase (1)	Impacts Due To Both Criteria (2)
	<=0	1-4	5-9	10-14	15-19	20-24	>=25		
Greensboro Bypass, west of US 220 Interchange	0	14	10	4	0	0	0	4	0
Greensboro Bypass, east of US 220 Interchange	9	17	12	3	1	0	0	4	1
Totals: Bypass Section AB	9	31	22	7	1	0	0	8	1
US 220, north of Greensboro Bypass	0	147(3)	0	0	0	0	0	0	0
US 220, south of Greensboro Bypass	0	5	0	0	0	0	0	0	0
Totals: US 220	0	152(4)	0	0	0	0	0	0	0

NOTES:

(1.) As defined by only a substantial increase (See Table 3).
(2.) As defined by both criteria in Table 2 and Table 3.
(3.) Includes two schools and one athletic field.
(4.) Increases in noise levels are a result of predicted increases in traffic volumes on US 220. No major construction or horizontal alignment shifts are proposed for US 220.

Table 8
Relationship Between Change In Decibel Level, Energy, and Loudness

Change In A-Level	Remove _% of Energy	Divide Loudness by _
3 dBA	50	1.2
6 dBA	75	1.5
10 dBA	90	2.0
20 dBA	99	4.0

Table 9
Barrier Attenuation

Reduction In Sound Level	Reduction In Acoustic Energy	Degree of Difficulty
5 dBA	70%	Simple
10 dBA	90%	Attainable
15 dBA	97%	Very Difficult
20 dBA	99%	Nearly Impossible